UNIVERSITI PUTRA MALAYSIA

VALIDATION OF THE MPSIAC MODEL FOR SEDIMENT YIELD PREDICTION IN ZARGEH WATERSHED, IRAN

RAMIN SAFAMANESH.

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By

RAMIN SAFAMANESH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

May 2004

DEDICATION

TO

Memory of my father whom his spirit will always
Be a part of mine

My wife for years of love and dedication, and
My twin sons whom their presence enriched my life

Thanks to Allah

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in Fulfilment of the requirements for the degree of Master of Science

VALIDATION OF THE MPSIAC MODEL FOR SEDIMENT YIELD PREDICTION IN ZARGEH WATERSHED, IRAN

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May 2004

Chairman: Associate Professor Wan Nor Azmin Sulaiman, Ph.D.

Faculty: Science and Environment Studies

Watershed degradation due to soil erosion and sedimentation is considered to be one of the major environmental problems in Iran. In order, to address the critical conditions of watershed degradation as well as insufficient availability of hydrometric stations, a study on the validity of an empirical model (Modified Pacific Southwest Inter Agency Model) developed in the arid and semi-arid conditions in United States to predict annual average sediment yield to Iranian watershed's condition was carried out. The MPSIAC model incorporates nine environmental factors that contribute to watershed's sediment yield. These factors are surface geology, soil, climate, runoff, topography, ground cover, land use, channel and upland erosion. In this study, the model was developed for Zargeh watershed with an area of 8.8 square kilometers. The sources data for the model was obtained from available records on rainfall and river discharge and sediment (collected over 20 years), topography, land use, geology and soil maps as well as from field surveys and laboratory analysis. Geographic Resources Analysis Support System (GRASS) GIS

(version 5.0.0) was used to facilitate the spatial interpolation of the nine model parameters and interpretation of predicted sediment yield for the entire watershed. Twenty years sediment yield records from 1981 to 2000 were used to validate the simulated model results. Results of simple linear regression analysis between simulated results and actual field records indicated that there is a significant correlation ($P < 0.05$) with $r^2 = 0.6124$ and standard error =2868.2 ton/year. In the sensitivity analysis, it was found that the most sensitive parameters of the model in the order of importance are climate, channel erosion and runoff factors. Surface geology, soil and slope factors were found to be insensitive to model output. The results of the study clearly indicated that the model can be applied to the Iranian conditions with recommended improvements be made on method to interpret upland erosion factor. The study also revealed that the model is more suitable for predicting yearly average sediment yield on a long time basis. The interest for this kind of model may be to establish for long term watershed management plans or for zoning of watershed's soil erosion potential where precise accuracy is not important.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PENGESAHAN MODEL MPSAIC UNTUK MERAMALKAN HASIL SEDIMEN DI KAWASAN LEMBANGAN ZARGEH, IRAN

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Penurunan mutu kawasan lembangan disebabkan hakisan tanah dan sedimen merupakan salah satu masalah utama alam sekitar di Iran. Bagi menangani keadaan kritikal penurunan mutu kawasan lembangan dan kekurangan stesen hidrometrik, satu kajian kesahihan penggunaan model impirikal (MPSIAC) yang dibangunkan di kawasan gersang Amerika Syarikat bagi meramal purata tahunan hasil sediment di Iran telah dijalankan. Model "Modified Pacific South west Inter Agency Committee (MPSIAC)" mengambil kira sembilan faktor penyebab persekitaran kepada hasil sedimen dari kawasan lembangan. Faktor tersebut ialah ciri-ciri geologi permukaan, tanah, iklim, alir permukaan, topografi, tutupan permukaan, guna tanah, hakisan saluran dan tanah tinggi. Dalam kajian ini, model berkenaan telah didirikan bagi lembangan Zargeh yang mempunyai keluasan 8.8 kilometer persegi. Punca data yang diinput kedalam Model diperolehi dari rekod curahan hujan, luahan sungai dan sedimen (20 tahun), peta-peta topogafi, tanah, guna tanah, geologi dan juga dari kerja lapangan dan analisis di makmal.

Perisian GRASS GIS (Ver: 5.0.0) telah digunakan bagi interpolasi secara reruang bagi sembilan faktor hakisan dalam model berkenaan dan juga bagi pentafsiran ramalan hasil sedimen bagi keseluruhan kawasan lembangan. Rekod hasil sedimen sepanjang 20 tahun, dari 1981 hingga 2000 telah digunakan bagi membukti kesahihan keputusan ramalan model. Keputusan analisis linear regressi di antara keputusan ramalan model dengan rekod pengukuran lapangan menunjukan terdapat pertalian korelasi secara signifikan pada kertian ($P < 0.05$) dan $r^2 = 0.6124$ dengan ralat piawai 2868.2 ton/tahun. Dalam analisis sensitiviti, didapati parameter atau faktor yang paling sensitif kepada ramalan model secara berturutan ialah faktor iklim, hakisan saluran dan alir permukaan. Faktor ciri-ciri geologi permukaan, tanah dan cerun didapati tidak sensitif kepada keputusan model. Keputusan kajian ini menunjukan dengan jelas model berkenaan boleh digunapakai di Iran dengan syor pengubahsuaian kepada kaedah penilaian factor hakisan tanah tinggi. Kajian ini juga menunjukkan bahawa model ini lebih sesuai diguna bagi meramal purata tahunan hasil sedimen bagi jangka tempoh yang panjang. Keperluan kegunaan model jenis ini adalah lebih kepada pembentukan pelan atau goal pengurusan lembangan jangka panjang seperti penentuan zon berpotensi hakisan di mana ketepatan ramalan tidak begitu penting.

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I certify that an Examination Committee met on May 19, 2004 to conduct the final examination of Ramin Safamanesh on his Master of Science thesis entitled "Validation of The MPSIAC Model for Sediment Yield Prediction in Zargeh Watershed, Iran" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows;

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

RAMIN SAFAMANESH

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LIST OF ABBREVIATION

BLM: Bureau of Land management

DEM: Digital Elevation Model

EPM: Erosion Potential Model

FAO: Food and Agriculture Organization

GIS: Geographic Information System

GPL: General Public License

GRASS: Geographic Resources Analysis Support System

MPSIAC: Modified Pacific Southwest Inter Agency Committee Model

OF: Objective Function

PSF: Peak Stream Flow

PSIAC: Pacific Southwest Inter Agency Committee Model

RUSLE: Revised Universal Soil Loss Equation

SE: Standard Error

SSF: Soil Surface Factor

WEPP: Water Erosion Prediction Project

CHAPTER 1

INTRODUCTION

1.1 Background

Watershed degradation due to soil erosion is considered to be one of the major environmental problems in Iran .It is estimated that the average annual erosion rate of watershed in Iran is more than 20 times of the acceptable average level in the world (Jalalian , 1997). Erosion and sedimentation limit the most intensive use of half of the soils of the countries (Black,1981). Among the different kind of degradation, water erosion is the major land degradation problem in many part of the world. About 1093 million hectares of land in the world have been degraded due to water erosion (Subramanian, 2000).

Soil loss in Iran for the period 1950-1990 has increased from 500million ton to 2200 million ton per year. This means an increase of 4.4 folds in 40 years (Ahmadi , 1995). One of the most sensitive watersheds involved is Maroon watershed which is located in the south of Iran and north of the Persian Gulf. It has an area of 2802 km^2.

Overgrazing, dry farming and deforestation are known to be the major causes of watershed degradation in Iran (Jalalian , 1997).

Since the country is large and the volume of data involved is also large under special circumstances, the study is necessary to find solution and a possible quick assessment of soil erosion and sedimentation on a watershed scale.

1.2 Statement of problem:

Erosion control requires a quantitative and qualitative evaluation of potential soil erosion on a specific site, and this requires knowledge of the terrain; soil, cropping system and management practices.

In Iran, due to insufficiency of gauging stations, it is envisaged that an empirical model is essential. Preferably to incorporate with GIS to facilitate the prediction and the assessment of soil erosion rate, in a wide area such as a watershed.

In order to solve this problem, it is considered to use one erosion model which cover all agents on soil erosion, which also calculates the total of sediment produced by all kind of erosion .Therefore modified PSIAC model which is recommended for arid and semiarid area was used same study area.

1.3 Objective

The objectives of the study are;

a) To validate Modified Pacific Southwest Inter Agency Committee Model (MPSIAC) for sediment prediction in Zargeh watershed, Iran.

b) To interpret the sedimentation data for Zargeh watershed based on MPSIAC model using GIS.

CHAPTER 2

LITERATURE REVIEW

2.1 Watershed

The watershed is defined as a unit of land on which all the water that falls (or emanates from springs) collects by gravity and fails to evaporate and runs off via a common outlet. The physical parameters which could affect the hydrological functionally of a watershed are size, shape, topography, drainage, vegetation, geology and soil (McCuen , 1998) :

a) Size: The size of a watershed determines the quantity of precipitation received retained and disposed off.

b) Shape: The shape of watershed determines the length-width ratio that, in turn greatly affects the manner in which water is deposed off.

c) Topography: Length, degree and uniformity of slope affect the disposal of water and soil loss. Degree and length of slope also affect the time of runoff concentration and infiltration opportunities.

d) Drainage: Topography regulates drainage. Drainage density (length of drainage channel per unit area), the length, width, depth of main and subsidiary channel, main outlet, and its size depend on topography. Drainage pattern affects the time of concentration of runoff.